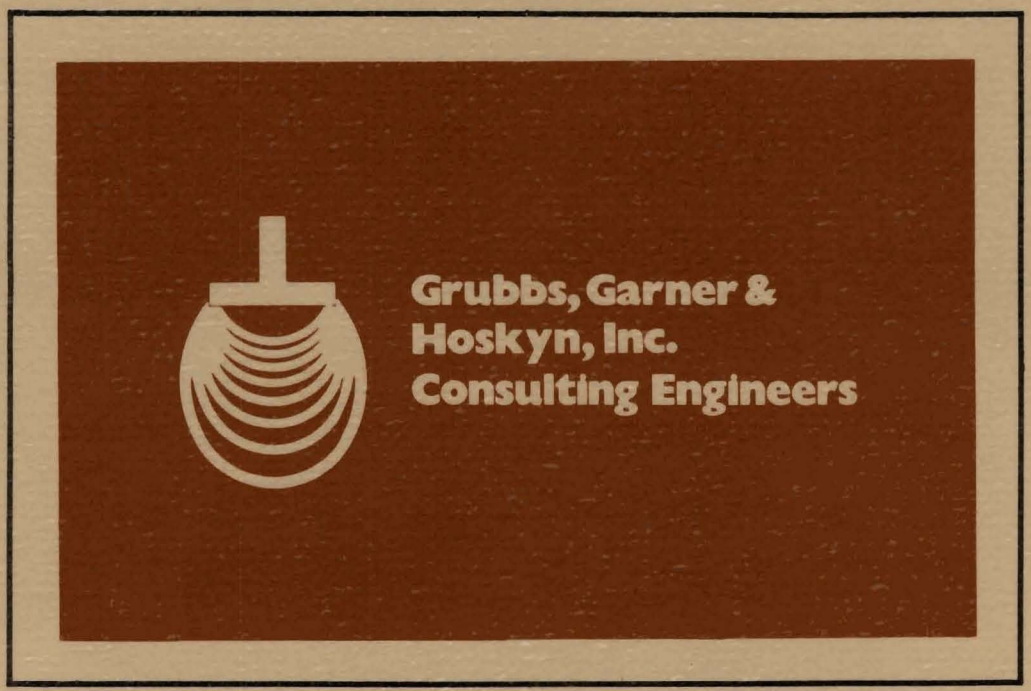
HYDROGEOLOGIC STUDY
CEDAR CHEMICAL CORPORATION
WEST HELENA, ARKANSAS

Report

to

CEDAR CHEMICAL CORPORATION
West Helena, Arkansas



JULY 1988

HYDROGEOLOGIC STUDY
CEDAR CHEMICAL CORPORATION
WEST HELENA, ARKANSAS

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CEDAR CHEMICAL CORPORATION
West Helena, Arkansas

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G R U B B S, G A R N E R & H O S K Y N, I N C.
Consulting Engineers
Little Rock, Arkansas

JULY 1988

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers
10501 Stagecoach Road
P.O. Box 5239
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July 19, 1988
Job No. LR88-134

Cedar Chemical Corporation
P. O. Box 2749
West Helena, Arkansas 72390

Attention: Mr. Joe E. Porter

HYDROGEOLOGIC STUDY
CEDAR CHEMICAL CORPORATION
WEST HELENA, ARKANSAS

Gentlemen:

Submitted herein is the report of the Hydrogeologic Study conducted for the Cedar Chemical Corporation Manufacturing Plant site located adjacent to Highway 242 in West Helena, Arkansas. This study was conducted in general accordance with our revised proposal and cost estimate dated April 21, 1988.

This report fulfills the program of study as outlined in our proposal letter. The services included review of published hydrogeologic data, drilling and sampling of soils, ground water level measurements, installation of piezometers in boreholes, field and laboratory testing, and analyses of the test results.

We have appreciated the opportunity to be of service to you during this phase of the study. If there are any questions with regard to the information presented herein, please contact us.

Sincerely,

GRUBBS, GARNER & HOSKYN, INC.

Richard E. Ackley, P.E.

John P. Hoskyn, P.E.
Vice President

REA/JPH/dgf

Copies Submitted: Cedar Chemical Corporation (4)
Attn: Mr. Joe Porter

INTRODUCTION

Project Description

A hydrogeologic study was conducted for the existing Cedar Chemical Corporation Manufacturing Plant site. This site is located adjacent to Highway 242 on the south side of West Helena, Arkansas. The area of this study is shown on the Vicinity Map as Plate 1.

The plant site is located on gently sloping to nearly flat-lying terrain. The plant includes chemical process units, and bulk and drum storage facilities. Biological wastewater treatment system lagoons are located west of the main plant area.

Purpose and Scope of Study

The primary purpose of this study was to define the hydrogeologic setting at the project site. The intended purpose was accomplished through the following program of study:

- Review of the existing subsurface data, hydrogeologic information, soil surveys, and other available information;
- Drilling of seven (7) sample borings and three (3) shallow auger borings on spacings of approximately 400 to 600 ft;
- Performing a laboratory testing program to measure permeability, plasticity, and grain size of the various soil types;
- Installation of a series of piezometers to assess the potentiometric surface of the uppermost aquifer;
- Conducting a general well survey in the immediate vicinity of the site;
- Completing a detailed geologic study of the site and surrounding area; and
- Performing analyses of the field and laboratory data and preparing a detailed hydrogeologic report to include: a) a discussion of geologic, ground water, and soil conditions; b) the hydraulic conductivity of significant strata; and c) ground water flow directions, gradient, surface contours, etc.

Report Format

Presented in this report are the results and recommendations that have evolved and developed from this study. Initial sections of this report describe the field and laboratory phases. These sections are followed by a description of the geology, ground water conditions, and general site and soil conditions. Subsequent sections of this report present results and conclusions.

FIELD STUDIES

Sample Borings

Subsurface conditions at the site were explored as follows:

Boring No.	Ground Surface Elev.*	Completion Depth, ft	Completion Elevation
1	194.0	48	146.0
2	195.3	140	55.3
3	195.2	43	152.2
4	194.8	53	141.8
5	196.8	48	148.8
6	194.1	150	44.1
7	194.4	46	148.4

* Elevations are for top of concrete pad surrounding protective casing.

The approximate boring locations are shown on the Plan of Borings, Plate 2. The ground surface elevations for the borings were determined using benchmark El 200.2 for the top of rail above the existing concrete culvert. The stratigraphy and results of field and laboratory tests are summarized on the boring logs, Plates 3 through 11. A key to the terms and symbols used on the log forms is presented as Plate 12.

The sample borings were drilled using a truck-mounted rotary drilling rig. Soil samples were typically obtained at 2-ft intervals through the upper fine-grained soils and at 5-ft intervals below that.

Cohesive soils were sampled using a 3-inch diameter thin-walled tube hydraulically advanced into the soil. Granular soils were sampled using a 2-inch diameter split-barrel sampler. The values (N-values) presented in the "Blows Per Ft" column on the boring logs represent the number of blows of a 140-lb hammer falling 30 inches to drive the split-barrel sampler.

All soil samples were removed from the samplers in the field and were visually classified by our soil technician. Shear strengths of cohesive soils were estimated in the field using a calibrated hand penetrometer. The estimated cohesion values are plotted on the log forms, in tons per sq ft, as small circles enclosing an "x". The samples were then sealed in appropriate containers for transfer to our laboratory for further testing.

Piezometer Installation

Borings 1 through 7 were advanced using wet rotary drilling procedures. Potable water obtained from the city water supply system was used as the drilling fluid. Borings 2A, 3A, and 6A were advanced using dry auger procedures. The purpose of Borings 2A, 3A, and 6A was to evaluate ground water conditions within the upper fine-grained soil strata.

Piezometers were installed in each of the boreholes. The piezometer riser pipe and screen consisted of threaded PVC pipe. The screen openings were machine-cut 0.010-inch slots. No. 2 blast sand was used for the filter pack around the slotted screen. A single, approximately 3-ft seal was constructed above the sand fill using bentonite pellets. A cement/bentonite grout was placed from the top of the bentonite seal to the ground surface. Protective steel casing was then set into the grout to enclose the PVC riser. The piezometer installation details are shown on Plate 13.

Field Permeability Testing

Variable-head tests were conducted on selected piezometers using both falling-head and rising-head procedures. Estimated permeability

values were computed using the data obtained and appropriate formulae (Hvorslev, U. S. Corps of Engineers, W.E.S.). The computed field permeability estimates are tabulated in a subsequent section of this report.

LABORATORY TESTING

Classification and Index Testing

Classification testing consisted of plastic and liquid limit tests and sieve analyses through the No. 200 sieve. The plastic and liquid limit and moisture content test results are plotted in accordance with the scale and symbols presented in the legend in the upper-right portion of each boring log form. The percentage of soil passing the No. 200 sieve is noted in the "Minus No. 200" column on the log forms. The results of the classification tests are summarized on Plates 14 through 16. Selected grain size curves are also shown graphically on Plate 17.

Permeability Tests

Laboratory permeability testing was conducted on undisturbed soil samples using falling-head test procedures.[1] In the falling-head test, de-aired water is allowed to flow under gravity through a specimen of known cross-sectional area, and the "head" loss is recorded. Computations are then performed for each test to determine the coefficient of permeability. The permeability test results are noted at appropriate depths on the log forms and are also tabulated on Plates 14 through 16.

SITE GEOLOGY

The project site is located in the Mississippi Embayment Physiographic Region. The surficial deposits at the site are composed of geologically recent alluvium of Quaternary Age. These deposits typically grade from silt and clay in the upper portion to sand with

1 Test procedures in accordance with T. W. Lambe, Soil Testing for Engineers, John Wiley & Sons.

gravel in the lower part.

At the project site, the thickness of the fine-grained soil cap is in the order of 25 to 40 ft. Portions of these upper soils apparently consist of outwash from Crowley's Ridge, as evidenced by the relatively high silt content. These soils likely represent swale-fill and flood-basin deposits.

The lower portion of the Quaternary unit consists of silty and very fine-grained sand to coarse-grained sand with some gravel. The alluvium generally becomes more coarse-grained and cleaner with increasing depth. These sand units are apparently channel-lag, channel-bar, and point-bar deposits.

On the basis of our sample borings, the base of the Quaternary sands is near El 50 to 60 at the project site. As shown on the Structural Contour Map (Plate 18), the base of the alluvial aquifer slopes downward to the southwest away from Crowley's Ridge. The contours shown are based on boring data in conjunction with the available U. S. Geological Survey Well Data.

The Quaternary alluvium is underlain by the undifferentiated Jackson-Claiborne Group. This unit crops out on Crowley's Ridge in Phillips, Cross, St. Francis, and Lee Counties. The Jackson Group was deposited primarily under marine conditions and typically consists of gray, brown, and green silty clay with some lignite. The upper portion of the Claiborne Group typically consists of silty clay with some interbedding of thin and discontinuous beds of sand and lignite. The Jackson-Claiborne clays act as a confining bed under the alluvial aquifer.

The upper clay of the Claiborne Group is underlain by the Sparta Sand in Phillips County. Sparta Sand consists mainly of gray, very fine to medium sand with brown and gray sandy clay. Most of the formation was deposited as the beach of an advancing sea. According to available U.S.G.S. mapping, the top of the Sparta Sand is present near El -200 (approximately 400-ft depth). The thickness of the sand is in the order of 300 to 400 ft. The Sparta sand is the major deep ground water aquifer in the area. The potentiometric

surface in the Sparta sand is near El 150, and the direction of flow is to the southwest.

WELL SURVEY

Domestic and industrial water supply in the area is obtained from the municipal system. As shown on Plate 19, the West Helena water supply is obtained from deep wells extending into the Sparta sand aquifer. According to U.S.G.S. information, the Sparta Sand well yields approximately 750 gallons per minute.

Wells within the Quaternary aquifer are present in the vicinity of the project site. These wells are used for irrigation and are in the order of 100 to 135 ft in depth. Yields range from approximately 700 to 1000 gallons per minute. The approximate well locations are shown on Plate 19. This information was obtained both from the U.S.G.S. files and from a local landowner.

GENERAL SOIL CONDITIONS

The stratigraphy encountered in the sample borings at the project site may be generalized as follows:

Stratum I: Interbedded very stiff to firm tan, gray, and brown silty clay (CL) and clayey silt (ML) was encountered at the ground surface over the project site to depths of 27 to 42 ft. The base of the upper fine-grained soils is near El 155 to 170. Coefficients of permeability in the silty clay portion were found to range from 8.5×10^{-8} to 3.0×10^{-7} cm/sec. In the clayey silt portions, the coefficients of permeability were found to range from 2.5×10^{-7} to as high as 4.0×10^{-5} cm/sec;

Stratum II: Medium dense to dense silty fine sand was encountered beneath Stratum I to depths of 134 to 143 ft. As shown on Plate 18, the base of the alluvial sand is at El 51 to 61 over the site. The upper portions of this stratum were found to be very fine-grained with a high silt content. Below depths of approximately 50 ft, the alluvium was found to generally consist of relatively clean fine to coarse sand with some gravel. As a

consequence, the lower portions of the sand are of much higher permeability. The permeability of this stratum is discussed in a subsequent section of this report; and

Stratum III: The basal stratum was found to consist of very stiff dark gray sandy clay with lignite. We anticipate that the coefficient of permeability of this stratum is less than 1.0×10^{-7} cm/sec.

To assist in discussion and visualization of subsurface stratigraphy, two (2) Generalized Soils Profiles were prepared and are shown on Plates 20 and 21. These profiles are considered to be representative of overall conditions. In using the profiles, it should be understood that the subsurface stratigraphy between borings was inferred from conditions encountered in the borings. Variations in stratigraphy and soil conditions should be anticipated. Additionally, the natural transition between alluvial soil types present at the site is generally gradual, and the indicated boundaries cannot be considered as precise.

RESULTS AND CONCLUSIONS

Hydraulic Conductivity

The hydraulic conductivity of the alluvial aquifer was estimated using both field and laboratory testing procedures. The results of the field variable-head ("slug") tests are as follows:

Piezometer No.	Depth of Interval Tested, ft	Type	Estimated Coefficient of Permeability, cm/sec
1	38 - 48	falling-head	3.6×10^{-5}
2	125 - 135	falling-head	2.4×10^{-2}
3	33 - 43	falling-head	2.1×10^{-4}
4	42 - 52	falling-head	2.8×10^{-5}
5	38 - 48	falling-head	5.1×10^{-5}
6	138 - 148	falling-head	2.5×10^{-2}
7	35 - 45	falling-head	7.1×10^{-4}
		rising-head	4.6×10^{-4}

As shown, the hydraulic conductivity of the deeper sands is in the order of 2.5×10^{-2} cm/sec. The hydraulic conductivity of the upper more fine-grained silty sands, however, is in the order of 3.0×10^{-5} to 5.0×10^{-4} cm/sec.

On the basis of grain size curves and the Hazen Formula, the permeability of the deeper sand units is in the order of 1.0×10^{-2} to 4.0×10^{-2} cm/sec. The hydraulic conductivity of the aquifer was also computed using a well formula for the yield and depth of the nearby irrigation well. On that basis, we computed a hydraulic conductivity of 3.0×10^{-2} cm/sec.

In summary, it appears that the hydraulic conductivity of the cleaner sand is approximately 3.0×10^{-2} cm/sec. Published data, however, indicates higher hydraulic conductivities in other portions of Phillips County. The lower hydraulic conductivity obtained at the site is apparently related to the silty and relatively fine-grained character of the sand.

The hydraulic conductivities of the upper silty clay and clayey silt soils were found to be quite variable. The cleaner and predominantly silt soils possess much higher conductivities than the silty clay soils. Hydraulic conductivities as high as 4.0×10^{-5} cm/sec were obtained for Boring 6.

Ground Water Movement

The ground water levels obtained on June 22, 1988 are as follows:

Piezometer No.	Ground Surface Elevation	Water Depth, ft	Water Elevation
1	194.0	27.9	166.1
2	195.3	28.9	166.4
2A	195.4	Dry	
3	195.2	28.9	166.3
3A	195.2	Dry	
4	194.8	28.8	166.0
5	196.8	30.2	166.6
6	194.1	28.3	165.8
6A	194.0	11.7	182.3
7	194.4	28.2	166.2

perched water zone

The potentiometric surface contours for June 22, 1988 are shown on Plate 22. The potentiometric surface slopes from El 166.6 in the eastern portion of the plant site to near El 165.8 near the southwest corner. In other words, the ground water surface is sloping generally to the southwest.

The data obtained in this study correlates relatively well with the Potentiometric Surface Map by the U. S. Geological Survey for fall of 1985. The regional direction of ground water flow was generally to the southwest towards a depression around and near the city of DeWitt.

As discussed previously, our analyses would indicate that the hydraulic conductivity of the deeper Quaternary sands is in the order of 3.0×10^{-2} cm/sec. Based on recorded water levels, we computed an average hydraulic gradient across the site of 0.0006. Using the aforementioned hydraulic conductivity and an average saturated thickness of 27 meters (90 ft), we computed a transmissivity of 700 m^2 per day (7,550 ft^2 per day). The velocity of flow through the sand aquifer is computed to be on the order of 0.02 meters per day (0.05 ft per day).

Published data indicates that the transmissivity of the alluvial aquifer in Phillips County is generally in the order of 34,000 to 35,000 ft^2 per day. At the site, however, the transmissivity is apparently reduced by the lower hydraulic conductivity of the fine sand and silty fine sand soils. Also, the transmissivity of the upper very silty fine sand soils was neglected in our computations. Due to the high silt content of this upper zone, the contribution to the overall transmissivity is relatively minor.

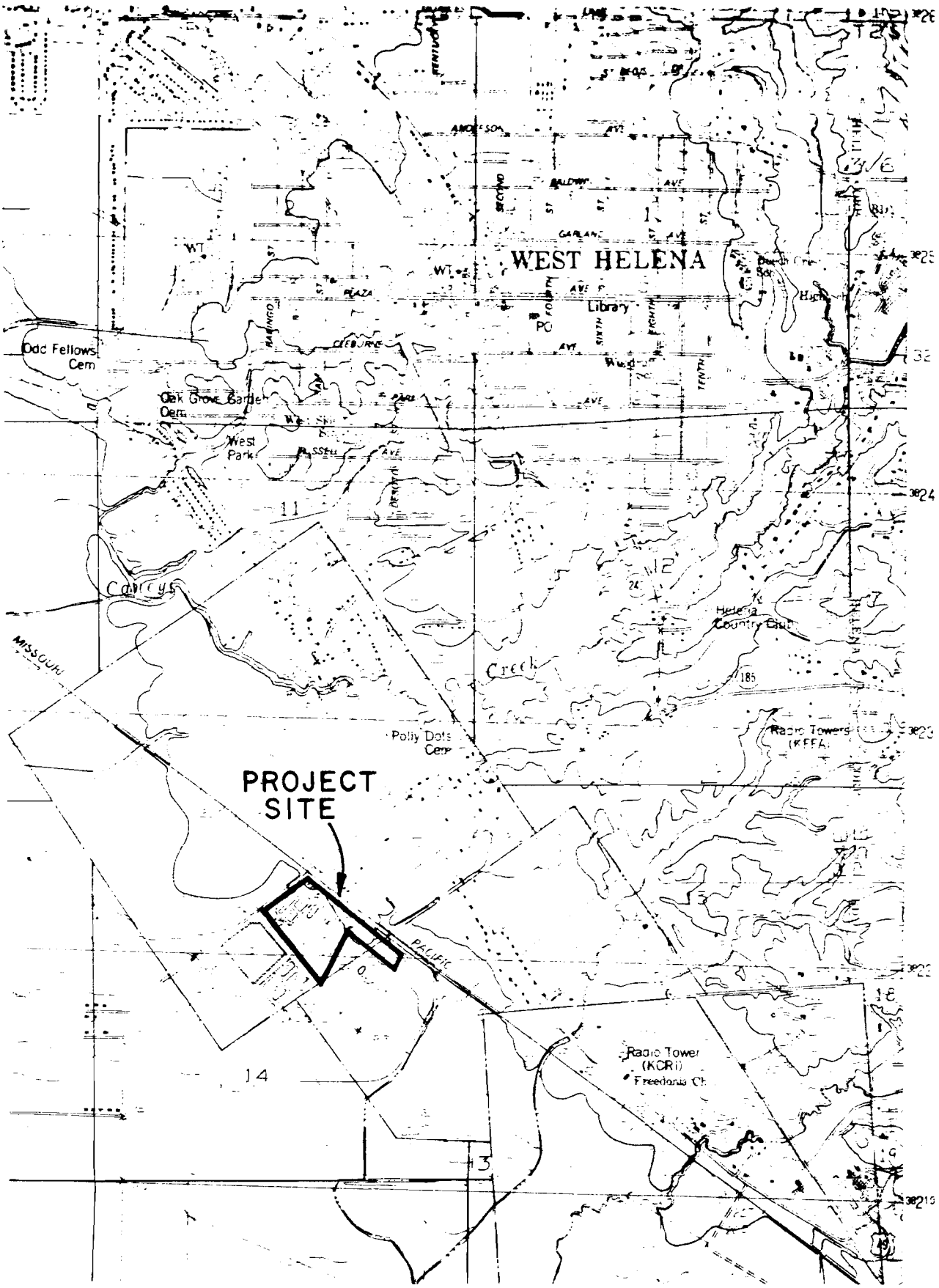
The recommended monitoring well locations are shown on Plate 22. These well locations are based on the recorded potentiometric surface of June, 1988 and the plant facility locations. These monitoring wells should be constructed to monitor the sand of the alluvial aquifer. Also, one (1) shallow well should be installed to monitor ground water quality within the "perched" ground zone observed in Piezometer 6A.

It should be noted that future ground water level measurements may possibly indicate a revised potentiometric surface and a differing direction of flow. Because of this, we suggest that the recommended well locations be reviewed at a later date on the basis of additional ground water flow data.

ADDITIONAL STUDIES

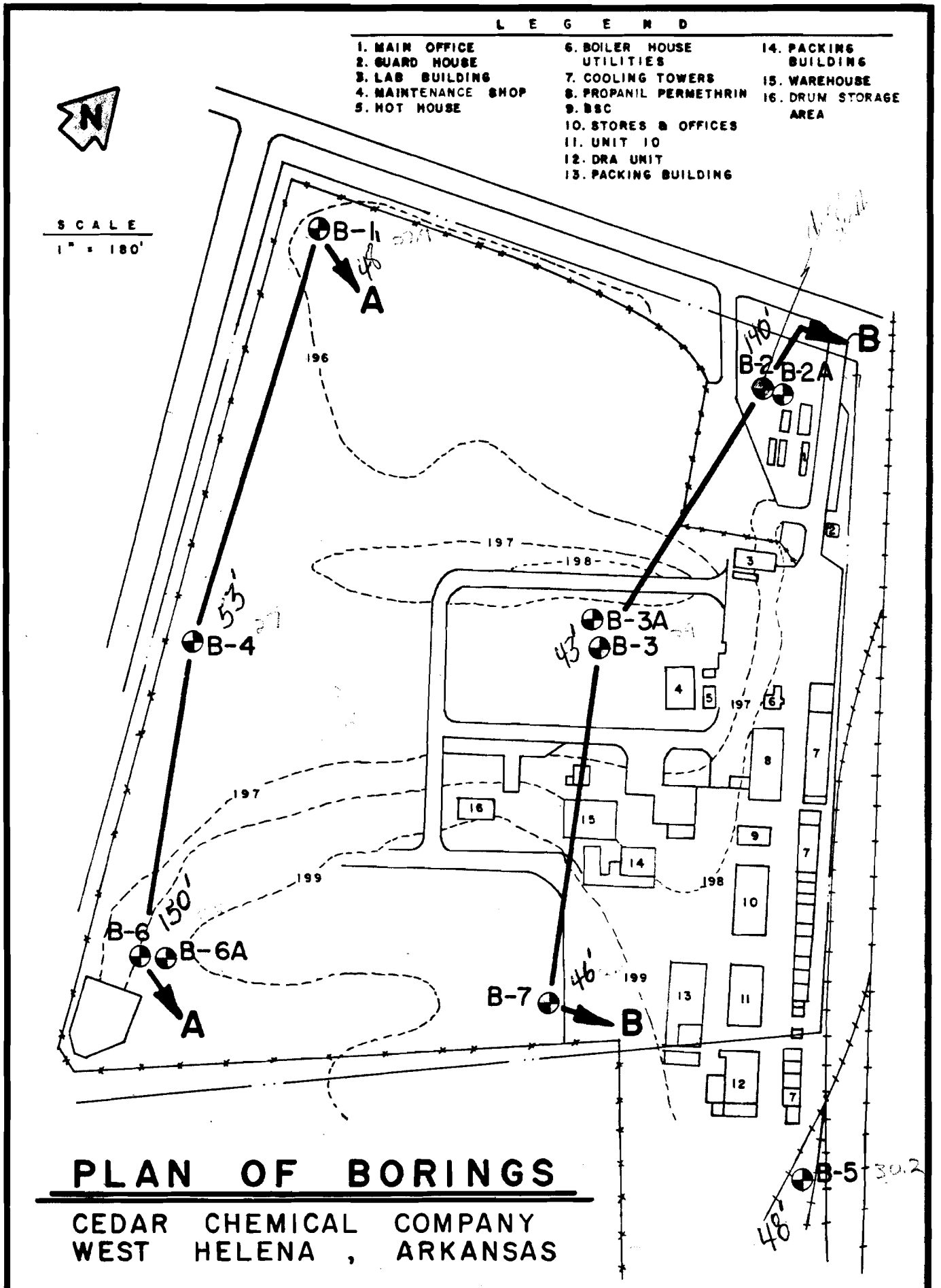
Additional water level readings should be obtained after the pumping season is completed. This should aid in assessing any seasonal changes in the potentiometric surface and the flow direction. It is possible that the heavy pumping for irrigation that took place at the time of our field studies may have locally altered the potentiometric surface and gradient.

Specifically, we suggest that the piezometer levels be measured periodically through the fall and winter until late spring of 1989. The late spring readings prior to pumping season should most closely reflect the natural potentiometric surface for the site.



VICINITY MAP

PLATE 1



PLAN OF BORINGS

CEDAR CHEMICAL COMPANY
WEST HELENA , ARKANSAS

BB-124

LOG OF BORING NO. 1

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash **LOCATION:** See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
			SURF. EL: 194.0				
			Very stiff to stiff brown clayey silt w/ferrous stains				
5			Stiff brown and tan silty clay				
			Firm to stiff tan and gray clayey silt				
10			Firm brown and gray silty clay w/ferrous stains		93	$k = 1.3 \times 10^{-7}$ cm/sec	100
15							
20			Medium dense brown and gray clayey silt w/ferrous stains Gray below 24 ft		85	$k = 1.9 \times 10^{-7}$ cm/sec	98
25							
30			Medium dense brown and gray silty fine sand				
35				22			
40				29			
45							
50							

COMPLETION DEPTH: 48 ft **DEPTH TO WATER IN BORING:** 27.9 ft
DATE: 6/15/88 **DATE:** 6/22/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 3

LOG OF BORING NO. 2

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash **LOCATION:** See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
			SURF. EL: 195.3				
5			Stiff to very stiff tan clayey silt				
10			Stiff brown and tan silty clay		95	$k = 3.0 \times 10^{-7}$ cm/sec	98
15			Firm brown clayey silt				100
20			Firm to soft gray and brown silty clay to very silty clay w/ferrous stains and rootlets				
25			Gray below 24 ft				
30			Dense tan and gray silty fine sand w/gray sandy silt seams at 29 to 30 ft	37			
35				51			
40				48			7
45				50			
50			-fine to medium sand below 48 ft	78/15"			
				75/13"			

COMPLETION DEPTH: 140 ft **DEPTH TO WATER IN BORING:** 27 ft **DATE:** 6/8/88
DATE: 6/8/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 4

LOG OF BORING NO. 2 (CONT.)

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash **LOCATION:** See Plate 1

SCALE CHANGE

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	% - No. 200
			SURF. EL: 195.3				
60				48			
				50			
70				53			
			Some gravel 72 to 72.5 ft and 75 to 78 ft	50			
80				82/13"			
				78/15"			
				83/13"			
90				80/13"			
			Some gravel at 97 to 103 ft	50/6"			
100				50/6"			
			Gravel frequent 106 to 107 ft	37			
110				80/15"			
				50/4"			
120				50/4"			
				50/4"			
130							
			Very stiff dark gray sandy clay and silty clay -w/light gray sand pockets	40			56
140				41			

COMPLETION DEPTH: 140 ft **DEPTH TO WATER IN BORING:** 27 ft **DATE:** 6/8/88
DATE: 6/8/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 5

LOG OF BORING NO. 3

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash

LOCATION: See Plate 1

SURF. EL: 195.2

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
	Fill: Crushed stone and silty clay				
5	Stiff brown silty clay with ferrous stains and clayey silt pockets and seams (odor)				
10				k = 8.5×10^{-8} cm/sec	100
15	Stiff to firm gray and tan clayey silt to very silty clay -less clayey below 18 ft (odor)		93	k = 1.9×10^{-6} cm/sec	99
20					
25	Firm gray and brown very silty clay w/ferrous stains (odor)				
30	Firm to soft brown and tan clayey silt w/ferrous stains Gray below 28 ft w/some fine sand	23			
35	Medium dense to dense gray silty fine sand (wet)	28 32			
40		38			18
45					

COMPLETION DEPTH: 43 ft
DATE: 6/20/88

DEPTH TO WATER IN BORING: 29 ft
DATE: 6/20/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 6

LOG OF BORING NO. 4

Chemical Chemical Company
West Helena, Arkansas

TYPE: Wash

LOCATION: See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
			SURF. EL: 194.8				
5			Stiff tan clayey silt -w/some silty clay pockets				
10			Stiff gray silty clay -w/ferrous stains and nodules -tan and gray below 8 ft		101	$k = 2.5 \times 10^{-7}$ cm/sec	90
15			Stiff tan and gray clayey silt -w/some silty clay pockets and seams				
20			-firm and wet below 18 ft				
25			-gray below 24 ft		97	$k = 1.6 \times 10^{-6}$ cm/sec	100
30			-more clayey below 32 ft				
35			Firm gray silty clay with organic matter Gray and brown below 36 ft				
40							
45			Dense gray silty fine sand				
50				36			

COMPLETION DEPTH: 53 ft
DATE: 6/15/88

DEPTH TO WATER IN BORING: 27 ft
DATE: 6/15/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 7

LOG OF BORING NO. 5

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash **LOCATION:** See Plate 1

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
			SURF. EL: 196.8				
5			Very stiff gray and tan very silty clay to clayey silt			$k = 4.9 \times 10^{-6}$ cm/sec	
			Stiff tan silty clay		96		100
10			Stiff tan clayey silt				
15			Firm brown and tan silty clay (Moist) to clayey silt				
20							
25			Firm gray and brown silty clay w/ferrous stains				
30			Firm gray and tan clayey silt -w/some fine sand				
35			Dense tan silty fine sand	32			
40				45			
45				40			
50							

COMPLETION DEPTH: 48 ft **DEPTH TO WATER IN BORING:** [illegible] ft **DATE:** 6/22/88
DATE: 6/17/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 8

LOG OF BORING NO. 6

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash

LOCATION: See Plate 1

SURF. EL: 194.1

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
	Stiff to soft brown silty clay w/clayey silt pockets				
5	Stiff to firm tan clayey silt w/ferrous nodules				
10	Stiff gray and brown silty clay w/ferrous stains and clayey silt pockets (odor)				
15	Firm gray and tan clayey silt (odor above 17 ft)				
20				k = 4.0×10^{-5} cm/sec	
			95	Non-plastic	100
25	-gray w/some silty clay seams below 28 ft				100
30					
35					
40					
45	Dense gray silty fine sand -less silty and coarser with increasing depth	36			
50		40			
		46			

COMPLETION DEPTH: 150 ft
DATE: 6/13/88

DEPTH TO WATER IN BORING: 26 ft

DATE: 6/13/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 9

LOG OF BORING NO. 6 (CONT.)

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash

LOCATION: See Plate 1

SCALE CHANGE

SURF. EL: 194.1

DEPTH, FT	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT
60	-fine to medium sand below 57 ft	51	
		56	
70		83/10"	
	-tan and gray w/some gravel below 76 ft	78/12"	
80		51	
		60	
90		57	
		50/7"	
100		56	
		78/15"	
110	-mostly fine sand 108 to 112 ft	50/7"	
		50/6"	
120		50	
		77/16"	
130		72/14"	
140		80/11"	
	Very stiff dark gray sandy clay w/lignite layers	50/7"	
150		70/16"	

COHESION, TON/SQ FT: 0.2 0.4 0.6 0.8 1.0 1.2 1.4

PLASTIC LIMIT + WATER CONTENT, % ● LIQUID LIMIT +

10 20 30 40 50 60 70

- No. 200, %: 3, 9

COMPLETION DEPTH: 150 ft
DATE: 6/13/88

DEPTH TO WATER IN BORING: 26 ft
DATE: 6/13/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 10

88-134

LOG OF BORING NO. 7

Cedar Chemical Company
West Helena, Arkansas

TYPE: Wash **LOCATION:** See Plate 1

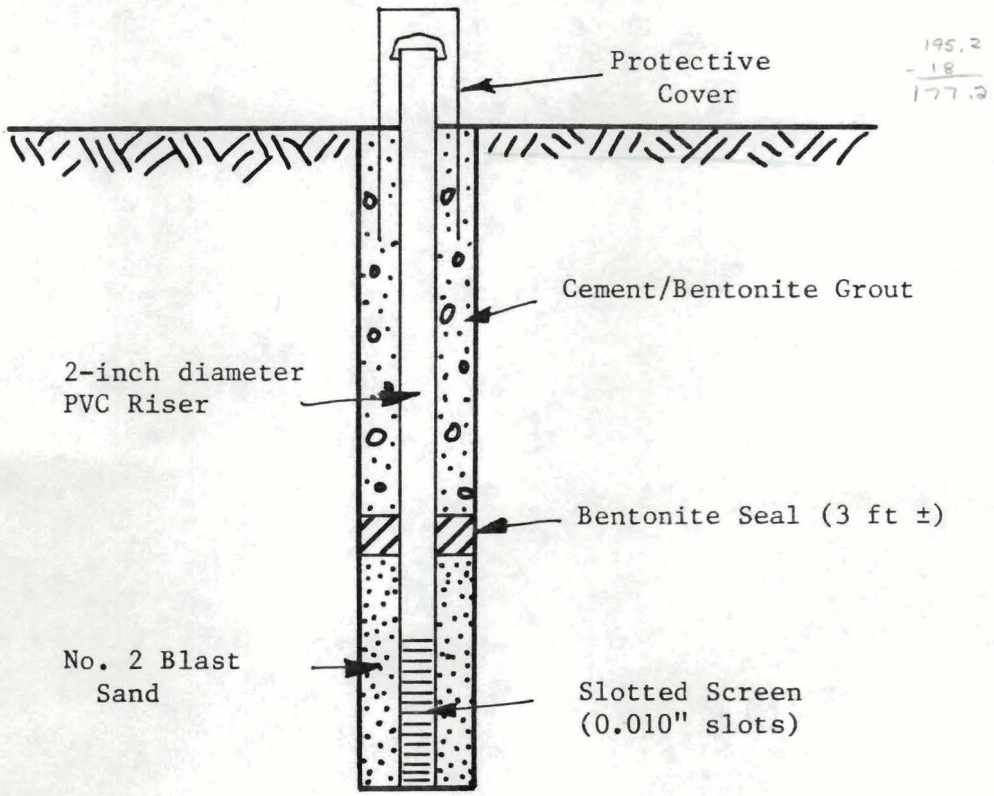
DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	COHESION, TON/SQ FT (0.2 0.4 0.6 0.8 1.0 1.2 1.4) / PLASTIC LIMIT — WATER CONTENT, % — LIQUID LIMIT (10 20 30 40 50 60 70)	- No. 200, %
			SURF. EL: 194.4				
5			Very stiff to stiff brown and tan silty clay w/ferrous stains and clayey silt pockets and seams				
			Brown and gray below 4 ft				
10			Stiff brown and tan clayey silt w/ferrous stains				
15			Stiff tan very silty clay -w/clayey silt seams		92	$k = 1.3 \times 10^{-7}$ cm/sec	99
20			Soft to firm gray and tan to very silty clay to clayey silt w/ferrous stains		90	$k = 6.4 \times 10^{-7}$ cm/sec	97
25			Medium dense light gray fine sandy silt w/ferrous stains				
30			Stiff dark gray sandy clay w/shells				
			Dense tan and gray silty fine sand (wet) -gray below 30 ft				
35				32			
40				38			
45				43			

COMPLETION DEPTH: 46 ft **DEPTH TO WATER IN BORING:** 26 ft
DATE: 6/16/88 **DATE:** 6/16/88

Grubbs, Garner & Hoskyn, Inc.
Consulting Engineers

PLATE 11

PIEZOMETER NO.	GROUND SURFACE ELEVATION	SCREENED INTERVAL		FILTER SAND	
		DEPTH, FT.	ELEVATION	DEPTH, FT.	ELEVATION
1	194.0	38 - 48	156 - 146	29 - 48	165 - 146
2	195.3	125 - 135	70 - 60	28 - 140	167 - 55
2A	195.4	11 - 16	184 - 179	9 - 16	186 - 179
3	195.2	33 - 43	162 - 152	24 - 43	171 - 152
3A	195.2	13 - 18	182 - 177	11 - 18	184 - 177
4	194.8	42 - 52	153 - 143	32 - 53	163 - 142
5	196.8	38 - 48	167 - 149	30 - 48	159 - 149
6	194.1	138 - 148	56 - 46	40 - 150	154 - 44
6A	194.0	19 - 24	175 - 170	17 - 24	177 - 170
7	194.4	35 - 45	159 - 149	27 - 46	167 - 148

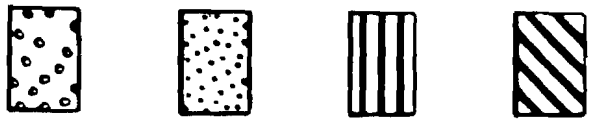


195.2
- 18
177.2

PIEZOMETER INSTALLATION DETAILS

SYMBOLS AND TERMS USED ON BORING LOGS

SOIL TYPES
(SHOWN IN SYMBOL COLUMN)



Gravel | Sand | Silt | Clay

Predominant type shown heavy

SAMPLER TYPES
(SHOWN IN SAMPLES COLUMN)

Shelby Tube | Piston | Split Spoon | No Recovery

TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS (major portion retained on No 200 sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests.

DESCRIPTIVE TERM	RELATIVE DENSITY
Loose	0 to 40%
Medium dense	40 to 70%
Dense	70 to 100%

FINE GRAINED SOILS (major portion passing No 200 sieve): Includes (1) inorganic and organic silts and clays, (2) gravelly sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests.

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH TON/SQ FT
Very soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very stiff	2.00 to 4.00
Hard	4.00 and higher

Note: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided – having inclined planes of weakness that are slick and glossy in appearance.

Fissured – containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical.

Laminated – composed of thin layers of varying color and texture.

Interbedded – composed of alternate layers of different soil types.

Calcareous – containing appreciable quantities of calcium carbonate.

Well graded – having wide range in grain sizes and substantial amounts of all intermediate particle sizes.

Poorly graded – predominantly of one grain size, or having a range of sizes with some intermediate size missing.

Terms used in this report for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No 3-357, Waterways Experiment Station, March 1953.

SUMMARY OF CLASSIFICATION TESTS

PROJECT: Cedar Chemical Company SITE: West Helena, Arkansas

SAMPLED FROM	LOCATION DEPTH, FT.	WATER CONTENT PERCENT (NATURAL)	L.L.	P.L.	P.I.	MECHANICAL ANALYSIS PERCENT FINER 3 IN.	3/4 IN.	3/8 IN.	NO. 4	NO. 10	NO. 40	NO. 200	PERMEABILITY, k_v cm/sec	CLASSIFICATION UNIFIED
B-1	13 - 13.5	29.6	37	24	13	-	-	-	-	-	-	100	1.3×10^{-7}	CL
	23 - 23.5	34.5	45	25	20	-	-	-	-	100	99	98	1.9×10^{-7}	CL
B-2	7 - 7.5	27.1	38	24	14	-	-	-	-	-	100	98	3.0×10^{-7}	CL
	13 - 13.5	30.4				-	-	-	-	-	-	100		ML
	39 - 40	22.9				-	-	-	-	100	99	7		SP
	134 - 135	21.1				-	-	-	100	99	97	56		CL
	139 - 140	24.3	40	16	24									CL
B-3	9 - 9.5	25.6	39	24	15	-	-	-	-	-	-	100	8.5×10^{-8}	CL
	17 - 17.5	28.6	32	26	6	-	-	-	-	-	100	99	1.9×10^{-6}	ML

PLATE 14

SUMMARY OF CLASSIFICATION TESTS

PROJECT: Cedar Chemical Company SITE: West Helena, Arkansas

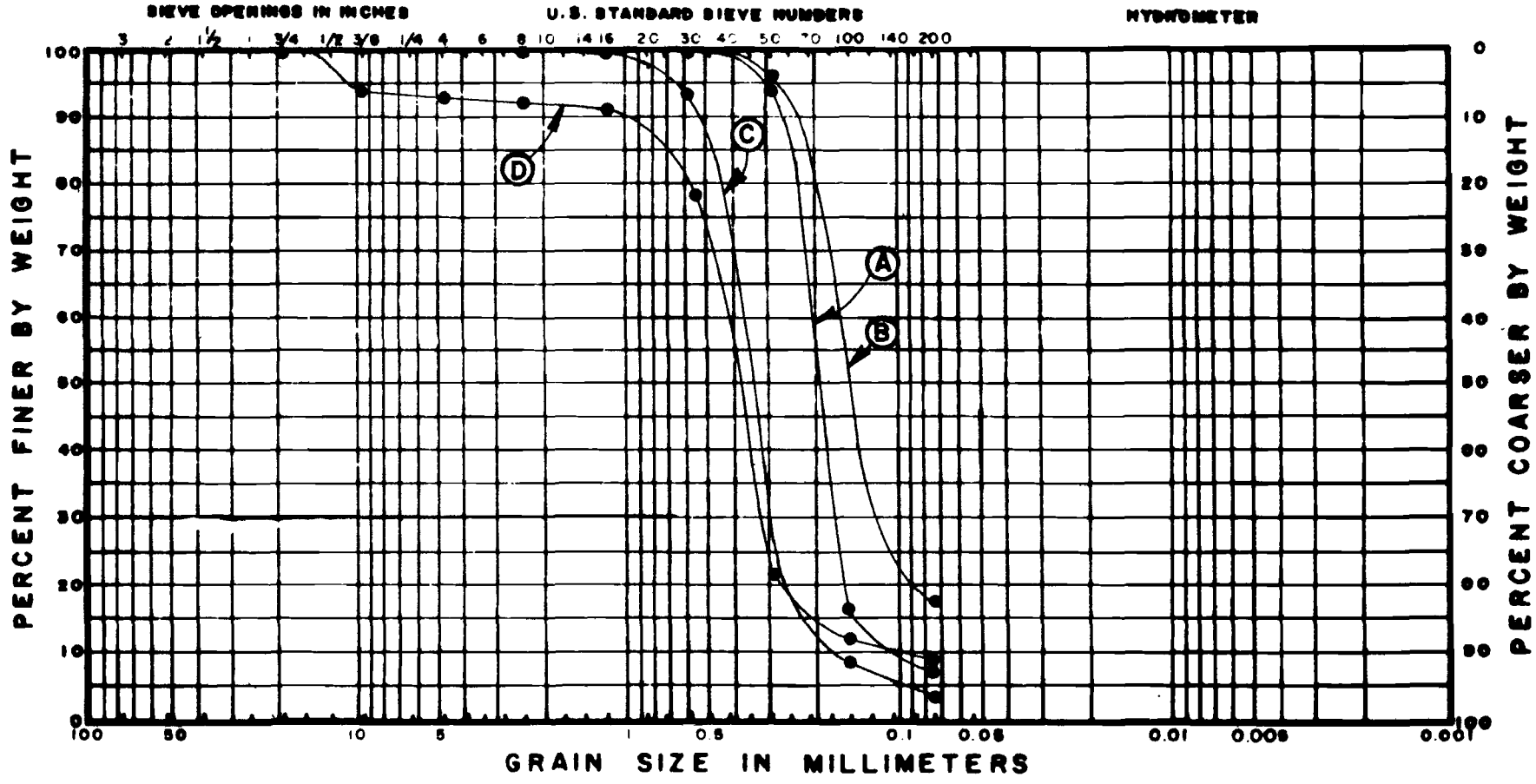
SAMPLED FROM	LOCATION DEPTH, FT.	WATER CONTENT PERCENT (NATURAL)	L.L.	P.L.	P.I.	MECHANICAL ANALYSIS PERCENT FINER 3 IN.	3/4 IN.	3/8 IN.	NO. 4	NO. 10	NO. 40	NO. 200	PERMEABILITY, k v cm/sec	CLASSIFICATION UNIFIED
B-3	40.5 - 41.5	25.3				-	-	-	-	100	99	18		SM
B-4	9 - 9.5	22.9	33	26	7	-	-	-	100	97	92	90	2.5×10^{-7}	ML
	27 - 27.5	27.8	28	26	2	-	-	-	-	-	-	100	1.6×10^{-6}	ML
B-5	7 - 7.5	24.0	36	26	10	-	-	-	-	-	-	100	4.9×10^{-6}	ML
	10.5 - 11	29.1	30	28	2									ML
B-6	23 - 23.5	28.1	Non-plastic			-	-	-	-	-	-	100	4.0×10^{-5}	ML
	25 - 25.5	30.5	29	28	1	-	-	-	-	-	-	100		ML
	59 - 60	19.4				-	-	-	-	100	77	3		SP
	119 - 120	23.0				-	100	93	93	91	61	9		SP

SUMMARY OF CLASSIFICATION TESTS

PROJECT: Cedar Chemical Company SITE: West Helena, Arkansas

SAMPLED FROM	LOCATION DEPTH, FT.	WATER CONTENT PERCENT (NATURAL)	L.L.	P.L.	P.I.	MECHANICAL ANALYSIS PERCENT FINER 3 IN.	3/4 IN.	3/8 IN.	NO. 4	NO. 10	NO. 40	NO. 200	PERMEABILITY, k v cm/sec	CLASSIFICATION UNIFIED
B-6	143.5 - 144	101.6				-	-	100	84	53	18	2	(lignite)	
B-7	13 - 13.5	28.6	34	24	10	-	-	-	-	-	100	99	1.3×10^{-7}	CL - ML
	24.5 - 25.5	33.1	32	26	6	-	-	-	-	100	98	97	6.4×10^{-7}	ML

GRAIN SIZE CURVES



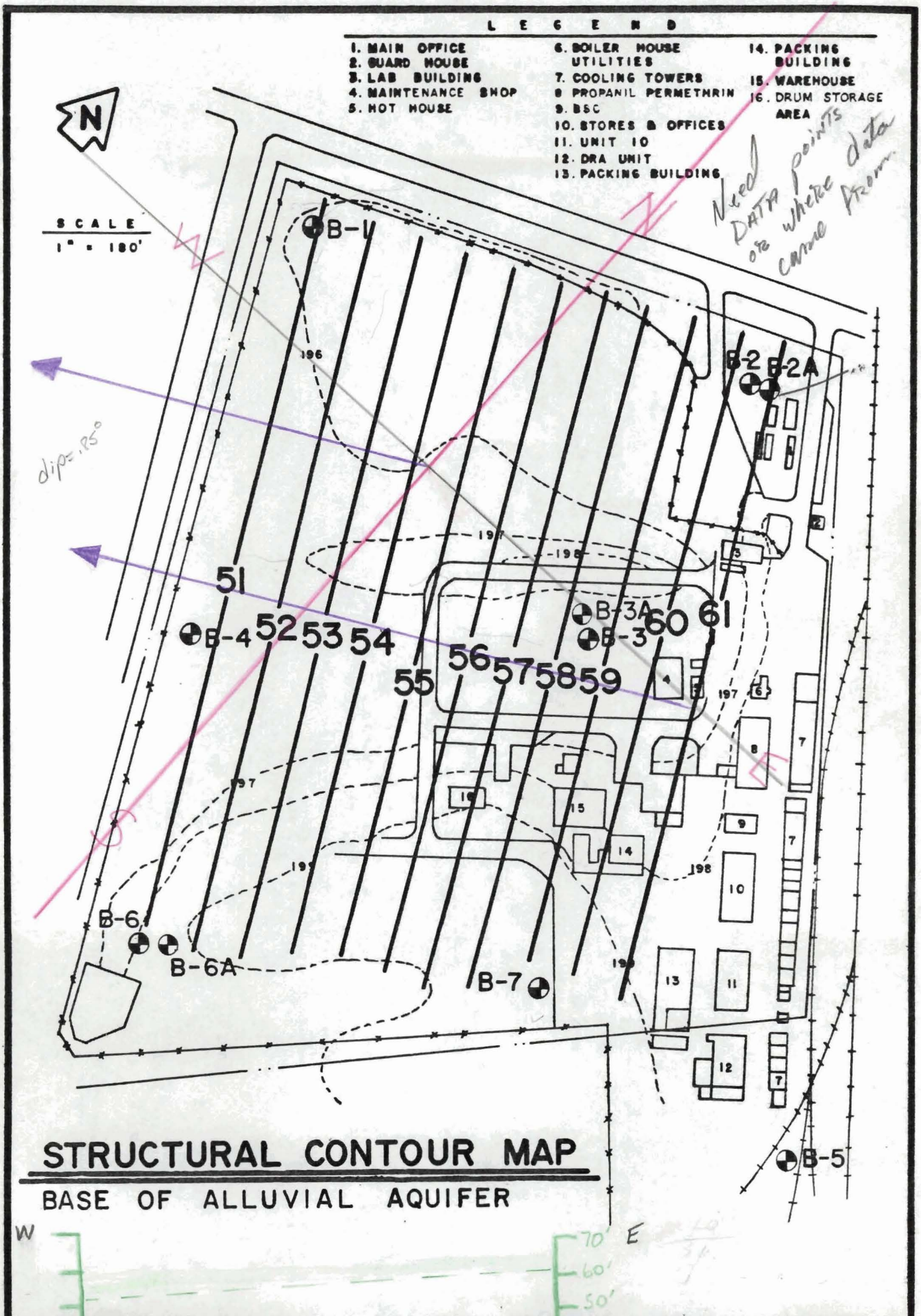
GRAVEL		SAND			SILT OR CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE	BORING	DEPTH, FT	D_{10}, cm	ESTIMATED PERMEABILITY,* cm/sec
A	2	39 - 40	0.011	1.2×10^{-2}
B	3	40.5 - 41.5	0.003±	9×10^{-4}
C	6	59 - 60	0.019	3.6×10^{-2}
D	6	119 - 120	0.011	1.2×10^{-2}

*Based on Hazen Formula

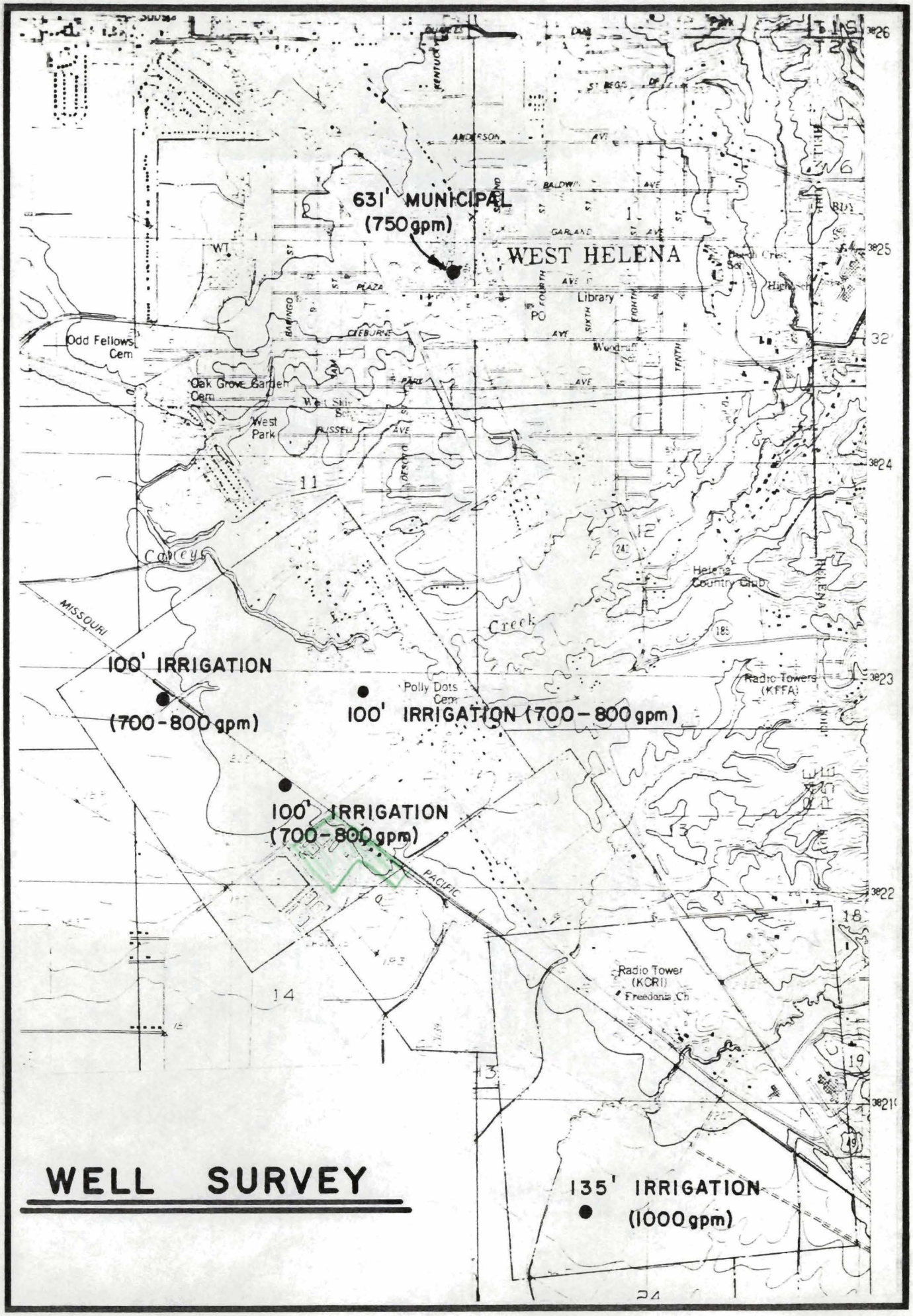
Grubbs, Garner & Hoskyn, Inc.

PLATE 17



STRUCTURAL CONTOUR MAP

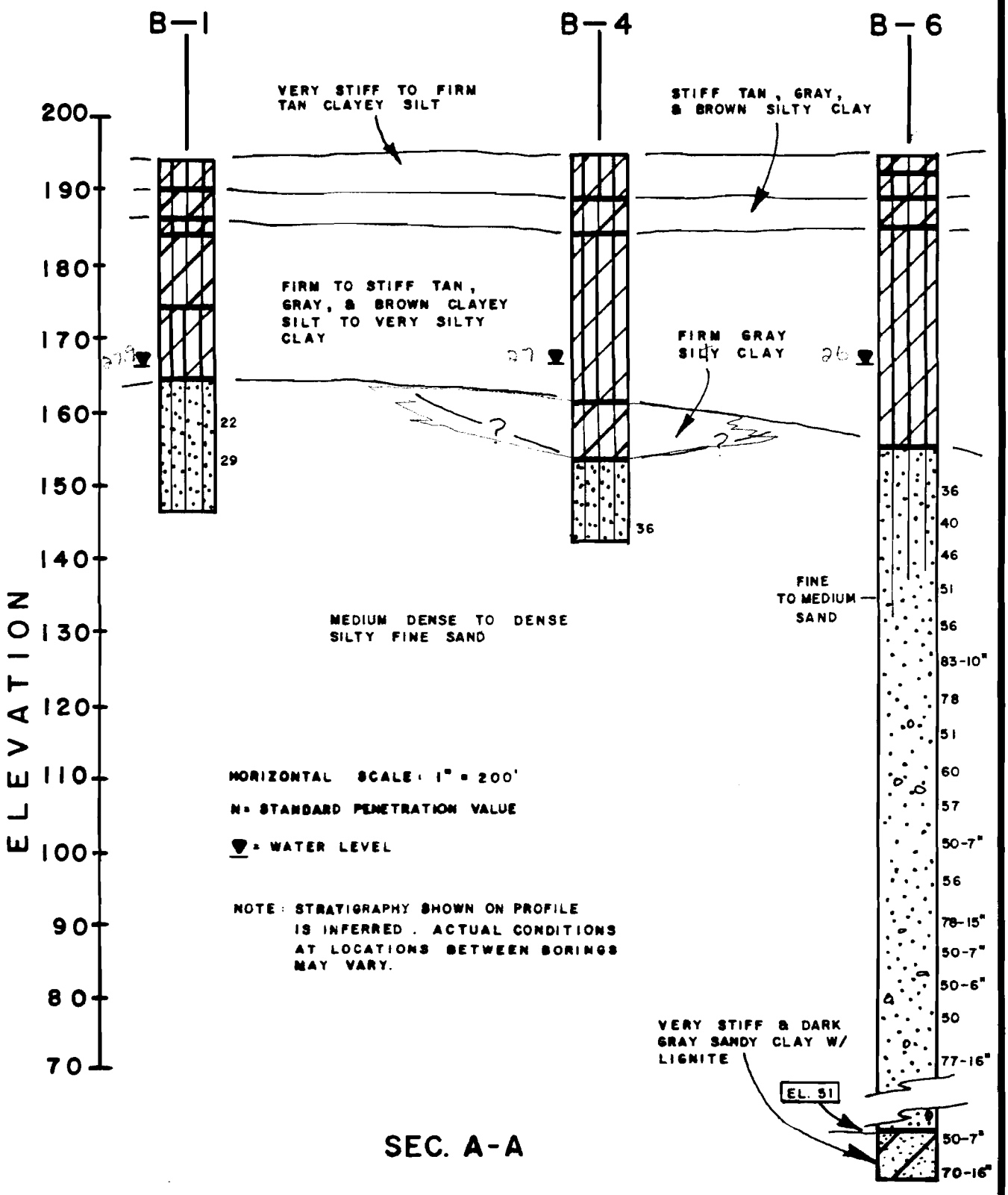
BASE OF ALLUVIAL AQUIFER



WELL SURVEY

PLATE 19

FORM DFT-1.0 (1978) Job No. 88-134

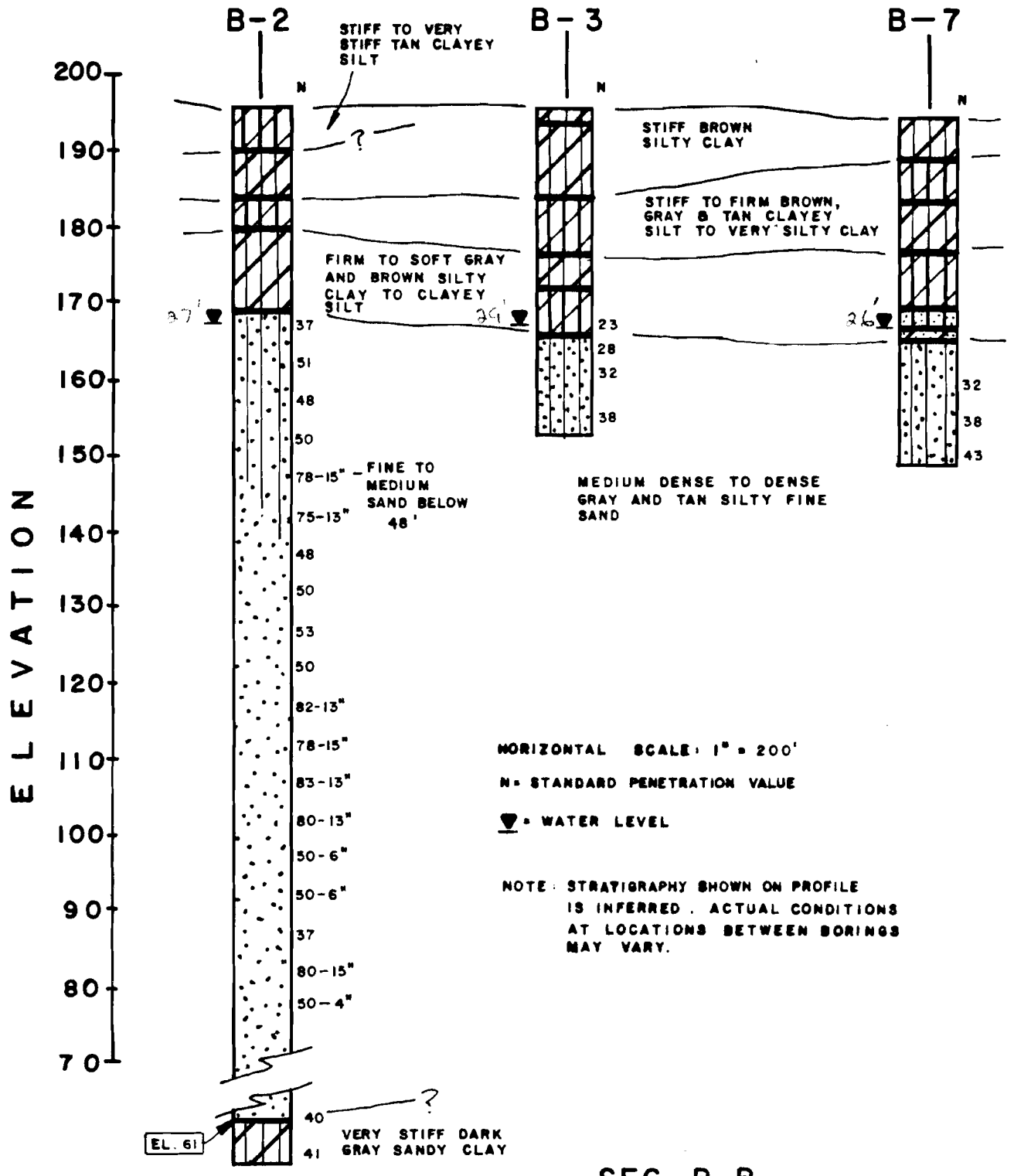


SEC. A-A

GENERALIZED SOILS PROFILE

CEDAR CHEMICAL COMPANY
WEST HELENA, ARKANSAS

PLATE 20



SEC. B-B

GENERALIZED SOILS PROFILE

CEDAR CHEMICAL COMPANY
WEST HELENA, ARKANSAS

PLATE 21